DOCUMENT RESUME

ED 479 491 HE 036 119

AUTHOR	Powers, Joshua B.
TITLE	Academic Innovation in the Commercial Domain: Case Studies of Successful Transfers of University-Developed Technologies.
PUB DATE	2003-04-00
NOTE	33p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, April 21-25, 2003).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC02 Plus Postage.
DESCRIPTORS	*College Faculty; *Educational Innovation; *Higher Education; Incentives; *Research Utilization; *Technology Transfer
IDENTIFIERS	*Commercial Applications

ABSTRACT

In recent years, considerable attention has been directed toward higher education's role as a driver of economic reform. Yet, surprisingly little is known about the processes and mechanisms by which academic innovations are successfully commercialized. The specific question is, what factors explain why some licensed innovations become bona fide products for societal benefits and other languish or fail? Based on case studies of successful transfers of university-developed technologies, this study offers insights on a set of issues surrounding the faculty inventor, technology transfer office, and licensing firm relationship that contribute to the knowledge of the technology transfer phenomenon. Case one focused on the discovery and commercialization of an innovative means of delivering pain medication to cancer patients. Case two explored the development and licensing of a tartar control product for pets and other animals. Case three focused on the development of an Internet-based video conferencing tool at a Northeastern university. Case four investigated the experience of faculty on opposite coasts with related research streams in neuroscience that ultimately partnered to develop a software aid for language skill development in children with learning skill difficulties. Three themes emerged from these studies: (1) the centrality of faculty involvement through all phases of development; (2) the importance of alignment of incentive structures with institutional and faculty culture; and (3) the importance of an environment of mutual trust and openness. (Contains 36 references.) (SLD)

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Academic Innovation in the Commercial Domain:

Case Studies of Successful Transfers of University-Developed Technologies

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April 2003
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Abstract:

In recent years, considerable attention has been directed toward higher education's role as a driver of economic development. Yet, surprisingly little is known about the processes and mechanisms by which academic innovations are successfully commercialized. Specifically, what factors help explain why some licensed innovations do become bone fide products for societal benefit and others languish or fail? Based on case studies of successful transfers of university-developed technologies, this study offers insights on a set of issues surrounding the faculty inventor, technology transfer office, and licensing firm relationship that contribute to our knowledge of the technology transfer phenomenon.

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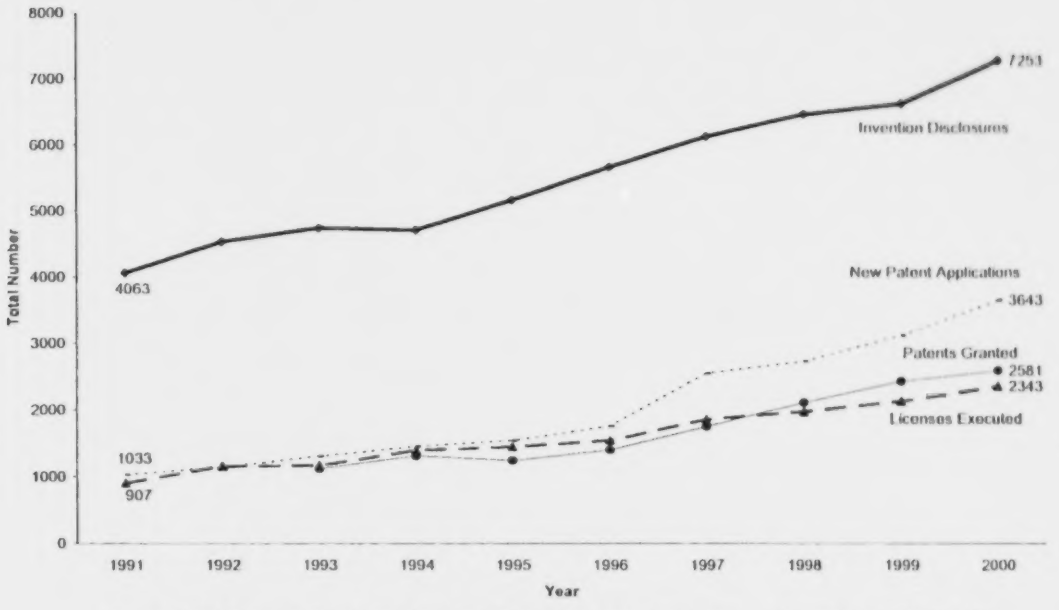
Introduction

Among the many issues confronting higher education in the 21st Century, one that has received particular attention in recent years has been the increasing involvement of colleges and universities in commercial activities. While commercial involvement is not necessarily new to higher education (Matkin, 1990), and ranges across a wide spectrum of activities, the scale and scope of one form of commercial engagement, technology transfer, has reached unprecedented levels. Stimulated in part by a favorable federal and state policy environment (Bowie, 1994; State Science & Technology Institute, 1997), increased legitimacy for embracing economic development as a core mission (Etzkowitz, Webster & Healey, 1998), and revenue contraction from traditional sources (Slaughter & Leslie, 1997), higher education, particularly research universities, have rapidly escalated their commercial involvement in technology transfer, the process by which a university developed technology is commercialized.

Data published by the Association of University Technology Managers (2001), clearly shows significant increases in the benchmark indicators of technology transfer engagement - faculty disclosures of potentially commercializable inventions, university patent applications, university patent issues, and licenses executed to industry. Figure 1 below shows how these indicators have trended over the past decade.



Source: AUTM Technology Transfer Data for 10 Year Recurrent Respondents; patents granted unavailable for 1991 and 1992

Figure 1: Invention Disclosures, New Patent Applications, Patents Granted, Licenses Executed

Over the period shown in Figure 1, the total number of invention disclosures to the university technology transfer office increased 79%, the number of patent applications increased 253%, the number of patents granted increased 131%, and the number of licenses executed increased 158%. Although not shown, the number of start-up company formations, new firms established specifically to develop a university licensed technology, increased 92% from 145 in 1994 to 278 in 2000.

Revenue trends from technology transfer have also markedly increased over this same time frame. Figure 2 below graphically depicts these increases.

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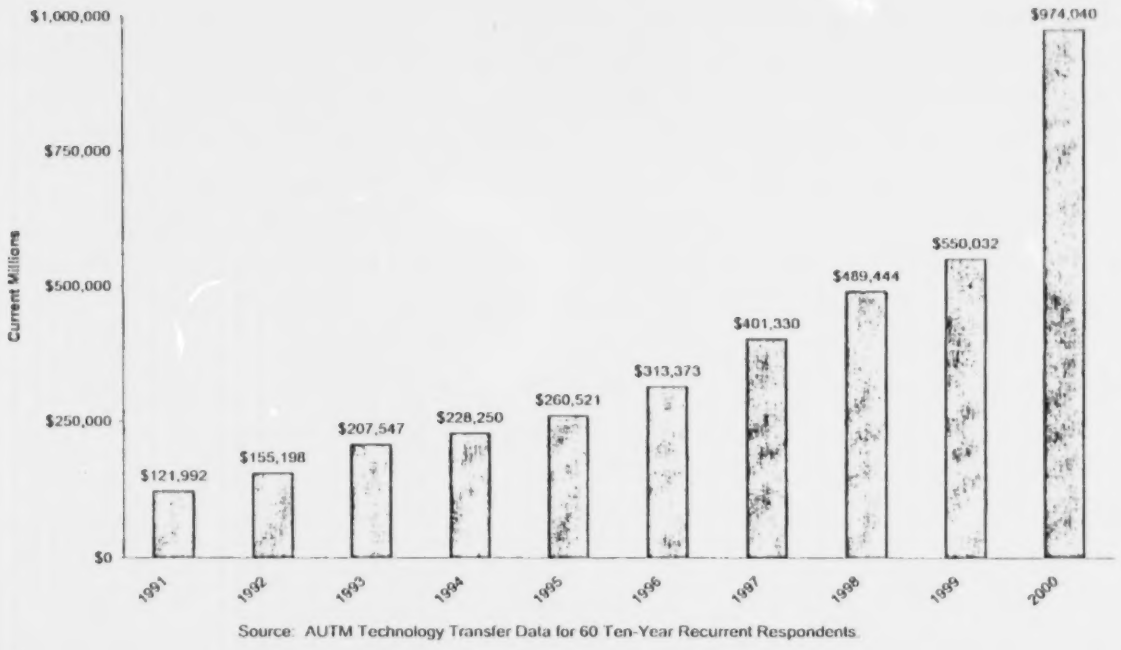

Figure 2: Licensing Income Trends: 1991-2000

Gross licensing income for the universities represented in the above figure increased 698% from $121 million to almost $1 billion. However, the primary beneficiaries of licensing income are a very small group of universities. For example, of the total $1.7 billion dollars in licensing revenues earned by all 140 respondents to the AUTM Licensing survey over the two year period 1999 – 2000, the top ten income producers generated $1 billion, 60% of all licensing revenues. Generally a very few very lucrative licenses such as the Hepatitis-B Vaccine at the University of California – San Francisco, Taxol at Florida State University, and Gatorade at the University of Florida account for the vast majority of revenues at the top income earning institutions. However, in some cases, the large revenues have resulted from successful patent infringement suits or sales of stock equity held by universities in their licensee firms.

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As a result of this accelerating involvement in activities seemingly in direct conflict with the historical values of the academy, much has appeared in the scholarly and popular literature expressing deep concern over the conflicts of interest that are occurring. Bok (2003), for instance, argued that in a quest to generate new sources of income, universities are eroding their social contract by compromising fundamental academic values. He cited growing secrecy expectations as a result of corporate-funded research and other conflicts of interest stemming from the growth in capitalistic interests within the academy. Researchers of the university commercialization phenomena have described the emergence of self-serving counter-values such as guarding scientific findings, pursuing intellectual property protections, and engaging in entrepreneurial activities for personal rather than altruistic purposes (Angell & Relman, 2002; Campbell, Louis, & Blumenthal, 1998; Slaughter & Leslie, 1998). A recent article in the *Atlantic Monthly* was even more emphatic of the dangers of a commercial orientation in higher education. Press and Washburn (2000) suggested that research universities are increasingly "kept", or beholden to commercial interests and acting like for-profit enterprises themselves, behavior that is undermining the paramount value of disinterested inquiry.

Despite the attention and ongoing clarion calls for reform, it is clear that higher education is pursuing the commercialization course with little likelihood of reversal. Yet, a relative paucity of research exists to inform its responsible practice. Thus, for instance, little is know about what makes for the successful commercialization of a university developed technology or what factors can typically derail the process by which a good idea in the lab is transformed into something of practical use to an end consumer, usually via a university-industry partnership effort. Furthermore, much is made of the few blockbuster success stories that just a handful of universities experience (Blumenstyk, 2002). However, the reality is that many university

licensed technologies never reach a product stage and/or result in only modest revenue streams for the institution (United States General Accounting Office, 1998). Nevertheless, success in terms of business development, entrepreneurial activity in a region, and significant, albeit not blockbuster, product sales, does occur with some regularity, an end point to which many institutions strive.

This study seeks to address the gap in knowledge about successful transfers of technology by investigating those factors associated with the faculty inventor, technology transfer office, and licensing firm relationship that facilitate the commercialization of an academic innovation. Based on case studies of four successful commercialization experiences that were chosen specifically for their richness of data and representativeness of the range of accepted measures of success with technology transfer, the research question I investigate is as follows:

What factors impact the successful commercialization of university developed technologies? More specifically, what aspects of the faculty inventor, technology transfer office, and licensing firm relationship influence the transfer and development of a technology into a commercialized product?

Conceptual Framework

Etzkowitz, Webster, and Healey (1998) use a triple helix metaphor to capture the nature of university-government-industry relations in our national system of innovation. They suggest that in recent years, the input-output linear flow model no longer adequately captures what is occurring. Instead, there is a blending or integration of the spheres (Etzkowitz & Leyersdorff, 1997). For example, industry has substantially increased its support of both basic and applied academic R&D (Mansfield, 1995) while universities have become more involved in

commercialization (AUTM, 2001). Government is also seeking to stimulate larger and speedier knowledge flows for economic development and regional or national competitiveness purposes (National Science Foundation, 1999; Teich, 1996).

Given the intertwined nature of the innovation process, of central importance to technology transfer is how the key players involved, the faculty inventor, the university technology transfer office, and the licensing firm interact in the pursuit of an end-stage product of practical utility to society. Research shows, however, that despite the helix like nature of the relationship, substantial differences in values exist between for-profit industry and academe (Louis & Anderson, 1998; Etzkowitz, 1998) with the technology transfer office attempting to mesh the two (Dill, 1995; Matkin, 1997). Thus, understanding the processes by which a university technology is licensed to industry and ultimately developed into a marketable product requires a knowledge of what is currently known about these three contributors to technology transfer.

University Faculty and the Technology Transfer Process

Thursby and Thursby (2000, 2002) studied the licensing activities of 64 universities and found that increases in licensing were due primarily to a cultural change among faculty and administrators interested in greater commercial engagement. However, some of their earlier work (Thursby & Kemp, 1999) revealed that those disciplines with strong external support for research (e.g., biological sciences) and an applied orientation (e.g., engineering) tended to have a culture more in alignment with industry and hence a willingness to engage in commercial activity. Yet, the traditional norms of academic science (Merton, 1942) are also powerful in these areas suggesting that a disciplinary explanation for differential performance with technology transfer may be simplistic (Argyres & Liebeskind, 1998). It is also clear that the

concerns over the commercialization of the intellectual commons are strongly embedded throughout higher education, suggesting that the real or imagined fear by faculty of technology transfer practice are a sizeable barrier to successful commercialization efforts.

Other research has suggested additional factors associated with faculty that are important to technology transfer. The most noteworthy of these include intentional administrative efforts to stimulate an entrepreneurial culture (Tornatzky, Waugaman & Gray, 2002), an overall high quality faculty in terms of research productivity (Powers, 2003), policies that allow faculty to accept stock equity in firms (Bray & Lee, 2000), and certain other faculty reward practices (Siegel, Waldman & Link, 2003).

Florida (1999), in his study of the technology transfer phenomena, argued that faculty talent enhancement did more to strengthen the value of institutions as an economic development engine than perhaps any other single action. Given how much the economic development mission of higher education has been resonating of late for states, it appears clear that faculty are a very important component in the technology transfer process. In sum, what the literature suggests is that a core competence of a university for technology transfer is the intellectual capital of its faculty and the degree to which an institution is able to leverage it for commercial endeavors.

University Technology Transfer Offices and the Technology Transfer Process

In their study of how university inventions get into practice, Colyvas et al. (2002) found that while faculty themselves were of considerable importance, the efforts of the technology transfer office was also important given its role in ensuring that firm-faculty relationships are supported and maintained, particularly in those fields where industry linkages are weak. This finding is one that others have also noted. Tornatzky, Waugaman, and Gray (2002), for instance,

suggested that the quantity and quality of technology transfer office staff are very important, especially their ability to catalyze an entrepreneurial spirit among key faculty as well as broker university-industry relationships. Other research has shown that various proxies for technology transfer office quality and capabilities such as the size of the staff, the age of the office, and the previous track record for commercialization are often predictive of technology transfer performance (Hauksson, 1998; Matkin, 1990; Powers, 2003).

Industry and the Technology Transfer Process

By comparison, relatively little is known about industry's involvement in university technology transfer or what they seek from universities for R&D. However, what research that has been done is informative for this study. Thursby and Thursby (2002) found that personal contacts faculty had with industry were the most common way industry became interested in licensing a technology, certainly more so than any intentional efforts by the technology transfer office to make industry aware of licensing opportunities. The authors also found that industry interest in university technologies was generally dependent upon how strong an emphasis industry placed on outsourcing R&D, particular of the basic kind, rather than developing new technologies themselves.

Mansfield (1995) and Mansfield and Lee (1996) also studied the technology transfer process from the industry side. In their studies of 66 firms in seven major industries, they found that large national or international firms with specific R&D needs from universities, generally also of the basic kind, tended to look nationally for faculty with the strongest reputations in their fields. However, proximity was also a consideration when seeking faculty for R&D work such that reputation might not always be the primary selection criterion, especially when it involved a particular applied research need.

Methodology

This study utilized a qualitative case study methodology and emerged from a previous quantitative study of university resource effects on technology transfer (Powers, 2003). Whereas the previous study identified a number of factors useful for explaining differential performance among universities in terms of patenting, licensing, and revenue generation from licensing, case studies of actual transfers of technology offers more fine grained insights into the phenomenon not typically possible via quantitative research (Creswell, 1998; Merriam, 1998).

Potential technology commercialization cases were identified via a three-step process. First, in the course of reviewing Securities and Exchange Commission filings of companies that made an initial public offering (IPO) built largely around a university licensed technology since 1995, I generated a list of potential licenses in which considerable detail on the technology and relationship to the university were disclosed in prospectus documents. From this list of 30 technologies, three were drawn based on their richness of information and that had achieved at least $500,000 in licensing revenues from product sales.

Given that some university technologies are licensed not to small, pre-IPO firms, but rather large established public companies, I identified a fourth case of this latter type for which the university had achieved the $500,000 in licensing revenues benchmark. This case was chosen based upon review of other public documents and discussions with licensing professionals.

In order to further ensure representativeness in the selection of cases, they were also chosen based upon geographical location (one from the West coast, two from the East coast, one from the Midwest, and one from the Rocky Mountain region) and the nature of the technology (medical device, video conferencing tool, dental care product, and educational software).

Furthermore, I chose cases that were not considered to be the blockbuster type (many millions of dollars in royalty revenues) since relatively few universities achieve that kind of success.

Interviews were conducted with persons most familiar with the respective technologies including the faculty inventor, the technology transfer office licensing official most connected with the experience, and the CEO or senior licensing executive at the licensing firm. Additionally, archival documents were also reviewed (e.g., licensing and marketing contracts, press releases, firm and technology transfer office web pages).

I followed a semi-structured interview protocol (Creswell, 2003) in which I inquired about the nature of the technology, the licensing experience, participant views on factors that led to the successful commercialization, and what participants saw as inhibitors to commercialization based on their extensive experience with other university-based technologies. All interviews were taped, transcribed, and chunked for convergent and divergent themes (Strauss, 1987).

Case Background

Case One focused on the discovery and commercialization of an innovative means of delivering pain medication to cancer patients. Developed by a faculty member based in a Rocky Mountain region medical school, this medical device represented a uniquely useful way of allowing a patient to self-regulate their pain medication via an oral lolly-pop like tool. In this circumstance, the faculty inventor sought and received institutional support to form his own start-up company around the licensed technology in an arrangement involving equity for both he and the institution. The company ultimately went public based on this and other related technologies. The firm was later acquired by a larger public company with a variety of drug products in the cancer, sleep, and neurological disorder areas.

Case Two explored the development and licensing of a tartar control product for pets and other animals. A faculty member based in a Midwestern dental school discovered a way that a tartar control substance could be adhered to rawhide bones, a useful means for managing tartar build-up in animal teeth via its quick release when in contact with saliva. Specific applications for the technology were licensed to various large, public companies with pet food or pet health related product lines. In addition, the product was licensed for use with exotic animals such as would be found in zoos.

Case Three focused on the development of an Internet-based video-conferencing tool at a Northeastern university. Developed primarily by two professionals located in a university computing center, this tool was the first of its kind to utilize Internet Protocol (IP) for real-time, desktop based video connectivity. Since prior to the commercialization early software versions were made available for free over the Internet, it generated considerable interest and exposure among persons interested in using it for videoconferencing. Two small, privately owned software companies ultimately expressed enthusiasm for licensing it from the university. The university chose to license it exclusively to one of the firms in return for royalties on product sales and stock equity in the firm. The university retained the rights for some related developments of the software. A few years later, a new licensing agreement was negotiated for which the university relinquished all of their rights to the software and more stock equity. The company continues to sell the product but is no longer the exclusive provider of video-conferencing software.

Case Four investigated the experience of faculty on opposite coasts (East and West) with related research streams in neuroscience that ultimately partnered to develop a software aid for language skill development in children with learning skill difficulties. Their computer-based

innovation enticed them to pursue the development of their technology via a start-up route. An exclusive, joint-institution licensing agreement that was negotiated with their respective universities, professional management and venture capital sought and obtained, and ultimately, a public offering milestone for the company achieved. The software and subsequent related tools have been sold to schools, to language development professionals, and to other individuals.

Findings

Rich data was extracted from the interviews and study of archival documents related to the four commercialization experiences. While there was much that was unique about each of the cases, three themes emerged from the analysis that appeared to be consistent across all of the cases and that both supports and extends what has been found in earlier, primarily quantitative, research. The three themes are described below.

Centrality of faculty involvement through all phases of development

The theme of faculty involvement was a consistent one articulated by all study participants as being important to success and most glaringly absent in failed or languished technology transfer experiences that they had either also participated in or had observed. For faculty inventors, one way that it was manifested was in a feeling that the firm in particular recognize who "gave birth" to the idea/prototype for which they had a high degree of ownership, that they did not wish to be "locked out" of post-license involvement, and that their rights to develop further refinements that might or might not be of interest to the firm be preserved. One faculty inventor described his feelings in this way:

> I was concerned that we retain the right to continue working on it [the technology]. I still had another couple of years on my grant and responsibilities to NSF and besides, we were

having a lot of fun doing it. We had a long discussion with the firm CEO about what we could do.

Another inventor offered specific examples of how faculty are important to the development of a technology after licensing including as a source of legitimacy for the firm's products:

> If there is an issue or problem, the inventor can often come up with an innovative way to solve that problem. Some of the other participatory roles for faculty may be to support research that the firm undertakes [post-license], help with product improvements, and as a source of additional research since in science, nothing is ever believed by the scientific community until it is confirmed by an independent group.

University technology transfer professionals spoke to the centrality of faculty issue in a similar way but added that it really required a faculty member who was both a leader in his or her field and an entrepreneur not afraid of venturing down the commercialization path.

> It is very important to have them involved throughout. We need the input from their side if we are talking to a company as a potential licensee. If the faculty inventor is unable or unwilling to work with the company, then the chances are that the technology is not going to be developed well. In this case, the inventor was very entrepreneurial. However, you see the entire spectrum. Some are very interested and others are not since they still see universities as ivory towers and thus working with a company is a form of selling out.

> The inventor's involvement in this case was pivotal. It is hard to imagine being able to sell an idea to a company without the scientific expertise of the faculty member, in our case it included a person with a neuroscientific background and another with a learning

disability background. It was great having people with those kind of credentials working with the company.

Representatives from industry spoke to the importance of faculty involvement after the licensing deal to interface with their in-house developers on the inevitable technical problems that arose, something that was carefully nurtured with the successful experiences. They also talked of a strong faculty and university tendency toward an "out of sight out of mind" and "be sure the royalty checks keep coming" attitude that often derailed otherwise potentially successful transfers.

> Once the deal is done, sometimes the academics loose interest and feel that now that their technology is licensed to a company, it is no longer interesting as an area of research. Why would they put their research efforts behind something that is plain old commercial? You always have this tension when the technology leaves their lab.

Like their university technology transfer office counterparts, industry representatives also valued faculty who had a healthy appreciation for the values of the for-profit sector. However, it appeared that those that could boundary span were more the exception than the norm.

> You know, there are a lot of scientists that are so focused and narrow that they really cannot see beyond their little niche of research and he [the faculty inventor in this case] is not like that. He has a real sense of wonder. He has always been intrigued with the business world. The idea of starting a business was interesting to him; he was not afraid to take a risk.

A sub-theme regarding the importance of faculty involvement after a firm licenses a technology was the potential synergies created. For example, one firm CEO spoke to the value of a faculty member for helping the company identify other faculty and institutions that conduct

research of interest to the firm or of future technologies the faculty member might develop for product enhancement or extension purposes. Another CEO talked about how having faculty inventors involved as consultants or even chief scientific advisors helped to ensure that good communication was maintained at all times and provided a valuable outside perspective on a specific technology application challenge. Depending on the field, the faculty inventor was also often as much or more aware of competitor products or those still in the development phase based on what they had learned through professional journals or conference meetings.

Alignment of incentive structures with institutional and faculty culture

As mentioned, previous research has shown that the culture and values of academic science is generally not in alignment with the norms and expectations of commercialization, a theme that also consistently emerged in this study. Yet, when a technology was transferred, its success was often attributed to the alignment of incentives for commercialization that matched the motivational tendencies of the respective parties. For example, university technology faculty inventors spoke to the importance of a variety of incentives beyond the royalty sharing policy to support faculty entrepreneurial activities including active concern for conflict of interest management. The following quote from one inventor captures this sentiment:

> My institution was quite concerned about conflict of interest issues with our company so they created a conflicts of interest committee for me that I really appreciated. It basically gave me back-up that we were thinking about these issues and doing our mutual best to manage them. They also put me up for a big state innovation award. We won it and the Director of the Technology Transfer Office had a big ceremony for us that was really nice.

Technology transfer office professionals interviewed had similar views on the importance of sensitivity to faculty needs and motivations:

> Our state conflict of interest laws in those days were quite onerous. We worked hard to work out some temporary escrow arrangements such that the inventor could be allowed to own more than one percent of the company. I've also done some other things to recognize faculty efforts here such as an annual patent award dinner for everyone that received a patent that year. We give them a nice plaque for their achievement and the university top brass come to show their support. I have also been asked to write recommendations for retention or promotion cases of faculty inventors that I have worked with over the years.

The culture of academe, and often the mismatch between it and that of business was often cited by interviewees as a significant explanatory factor in failed transfers of technology but that were largely overcome in these successful cases. Faculty inventors, for instance, spoke of a generally favorable climate in their institution for engaging in commercial activities but also mentioned the professional jealousies of some colleagues that were only overcome by strong institutional commitment to technology transfer and the proactive steps they and the institution took to manage the conflicts of interest. In the case of one inventor, for instance, it was clear that the institution's support of a sabbatical year in which she could devote her time largely to the development of her company was instrumental in moving the idea forward. It was also clear that the inventors in each of the cases were also active researchers, and it did not appear that their research activities suffered as a result of commercial engagement.

From the firm point of view, they spoke to the value of incentive alignment in the form of equity participation. Specifically, when the institution and faculty inventor had an equity stake

in the firm, all parties then shared ownership for the firm's success at commercializing the technology. It also demonstrated that the institution recognized that young firms are typically idea rich but resource poor. Yet with collective commitment, circumstances could change and benefit everyone. One CEO put it this way:

> I'm a firm believer that a university should always take at least some stock equity in a firm [when licensing to a small private firm]. There are too many horror stories about how an opportunity was lost because the university had a policy that its only form of return could be in up-front fees and royalties. I have to feel like we [the university, the faculty inventor, and the firm] are partners in this together... You put even ten shares of stock in the hands of an individual and I guarantee that they will start watching the NASDAQ every day. They become emotionally engaged in the process. It is good for the university. They then do not view the deal transaction as an isolated event but rather stay engaged over time with it. I want the university to enjoy the upside of equity.

The sub-theme of equity as an incentive tool was also voiced by technology transfer office staff and faculty inventors. In the case of technology transfer office professionals, they felt that contrary to the idealistic view of faculty as not being especially influenced by making money, their experience was that faculty do like the opportunity to augment their salaries and that a fair revenue sharing arrangement did stimulate interest in commercialization. Thus, given the increased pressure on universities to demonstrate their commitment to economic development in a region, technology transfer office professionals felt that mechanisms should exist by which faculty could take an equity position in a licensee firm. One interviewee, however, also articulated that having a policy that reserved some of the royalty revenues for the inventor's lab or department was also a big incentive. Thus, given faculty intrinsic desires to

conduct meaningful research of their own choosing, using some of the royalty revenue to modernize or expand a faculty member's lab or to have it shared with ones colleagues aligns the goals of the faculty member and the institution nicely.

Environment of mutual trust and openness

A third major theme that emerged was the importance of an environment of mutual trust and openness. In sum, all were in agreement that an important factor to the success of their technology was that each participant recognized what the others brought to the table and were up front about their own limitations, even those that would not have been expected. Faculty inventors, for instance, spoke of "knowing when I was out of my league," typically, but not always, when it came to running a company. By being honest with themselves and the values that drew them to academe originally, they deferred to others for finding appropriate firm management, venture capital, or other related needs to the development and sale of a commercial product. Some of the thinking along the lines of this theme was reflected in faculty inventor comments.

> It is really important to let them [the technology transfer office] support you and make sure you understand the policy environment and the patenting and licensing process. It is worth to do it up front and not try to do it on your own since you will surely make mistakes because it is complicated.

> I do think that faculty become a little distrustful of somebody [the technology transfer office] taking over their invention and even resentful that the university seems to be getting an increasingly large share of the royalties. However, they play an important role in the process.

Faculty inventors also expressed views on the issue of trust with the licensee firm. One inventor, for instance, expressed that the principle of fairness should be paramount in any technology transfer partnership. In their mind, the licensing firm had a big and risky job too, thus necessitating that the company be given adequate flexibility to grow and not be overburdened by a greedy university seeking to milk a license for as much as could be obtained, especially in the short term. "Don't try to sneak around and screw somebody by being stingy with equity to private investors, for example, since they are assuming a sizable risk too," this inventor said. Another inventor, however, described how difficult it was at first to get the licensee company to understand why he might want to have the right to work on a different but related aspect of the product and that doing so would not violate the licensing agreement.

For technology transfer professionals, trust was also a significant contributor to the success of a commercialization experience and one of the first things to derail it. One professional suggested that when faculty did not trust the technology transfer office to do their jobs and/or had unrealistic expectations for their invention, it was a recipe for disaster.

> Often the inventors who want to start a business do so for the prestige of it. I can't tell you how often, though, that the skills that make for a good scientist do not have anything to do with business. They have unrealistic expectations and it is hard to deal with them, especially when they have very prestigious reputations in their fields.

Another professional characterized the issue this way:

> There is always the potential for tension because we are basically a policy enforcement office. It is like the official office that tells you what you can and cannot do. It is the same with taxes. I mean there is a law that says you shall pay taxes and so we all have a bit of an antagonistic relationship with the IRS because they are collecting something that

we want. I think technology transfer offices across the country face this. Although we have faculty that take the technology "out of the back door" sometimes and bypass us, fortunately most see that we do play an important role and when they discover us, they go, "Wow, I did not know this existed!"

This professional then went on to describe the specific relationship that the office had with the inventor of the technology I was studying and suggested that trust was integral since they largely left the inventor alone to do what he did best. The inventor in turn reciprocated what he was supposed to do as it regarded submitting the appropriate royalty reports and related documentation.

Technology transfer office professionals also spoke to trust with the licensing firm. This fact was described in terms such as being open and honest in licensing deal negotiations, not misrepresenting their capabilities, and providing the appropriate due diligence, a term referring to built in product development milestone expectations that if violated gave the university the legal right to negate the deal and seek a different licensee firm. In one of the cases, it was clear that the first firm to whom the university had licensed a technology did in fact "drop the ball" via inadequately marketing the product. However, the due diligence clauses were not specific enough to do anything about it. Fortunately, after much effort on the university's part, the licensee firm finally relented and allowed the university to license the technology for a product area in which the original licensing firm did not compete.

For one of the technology transfer office professional interviewees, trust was especially important since the effort involved faculty researchers at different universities. In this case, careful consideration had to be given to who would play what role in the licensing negotiations and how the deal would be consummated. They worked through this by allowing one institution

to take the lead on the negotiations and when stock equity was offered, to structure the deal differently based on their respective equity policies. "It worked quite well," he said, "demonstrating how important good communication at an early stage is in a joint venture situation."

In the case of industry professionals, they too spoke to the importance of trust. For them, trust was manifested in reasonable views about the culture of higher education and its importance to the advancement of knowledge as well as feeling good when university personnel were respectful of the role that business plays. As it regards the latter, one industry participant said this of a trusting relationship with universities, "I've worked with university licensors in the past and they are often focused on how much more money they can get out of a licensing deal versus looking at what is best for the product and how that will benefit both of us." In describing the case investigated for this study, however, he felt all parties were focused on how to produce the right product given the university's willingness to be upfront with reasonable royalty percentage expectations. He then went on to express appreciation for the university's willingness to use lawyers only at the end of deal negotiations when the official license agreement papers would be prepared.

Discussion & Implications

In this study, I sought to investigate what factors impact the successful commercialization of university developed technologies and those aspects of the faculty inventor, technology transfer office, and licensing firm relationship in particular that influence the transfer and development of a technology into a commercialized product. The results revealed three broad themes that appeared especially salient in each case and that involved the interface between the three primary parties mentioned. In this section, I will discuss each of the theme areas in light of

previous research as well as the implications for the responsible pursuit of university technology transfer.

Centrality of Faculty Involvement

As mentioned previously, it was clear that faculty not only play an important role in the development and incubation of early stage ideas but that successful transfers of technology necessitate their continued involvement in the later stages of the process. This finding extends what has been found in previous research. Specifically, earlier research has shown that faculty are often the primary way that firms learn about and ultimately become interested in licensing a technology (Thursby & Thursby, 2002), but this study offered evidence of the importance of an ongoing partnership relationship between faculty member and firm. Typically, a technology emerging from a university is in a conceptual stage, often without a clear-cut application, at least not one that can be quickly brought to market. As such, the firm often carries the lion's share of the work needed to move what seems like a good idea in the laboratory to one that society can directly benefit. While this is especially true in the pharmaceutical and biotechnology industries, it is often true of other kinds of technologies, some of which were represented in this study. As such, the expertise of the faculty inventor is of great importance to assist with post-license product development needs and the practical realities of doing so within a cost-effectiveness framework.

Given the historical purpose of higher education research for producing largely basic science and industry's historically applied function, the centrality of faculty finding raises the question of whether or not universities and their faculty should be so heavily involved in the application side and/or if doing so undermines a distinct competency of U.S. higher education for R&D. Although answering this normative question is beyond the scope of this study, the results

do suggest that ways can be found to manage potential conflicts of interest that do not necessarily preclude some faculty from becoming involved in commercial activities. For instance, most institutions do have clear policies on conflicts of interest that require at a minimum full disclosure of commercially oriented involvement. Many universities, however, go much further by including policies that restrict faculty from serving in a firm officer capacity and/or offer escrowing arrangements for equity that restricts access to those resources for a set period of time. Some institutions are also experimenting with how to integrate technology transfer activity into the tenure, promotion, and performance evaluation process in a way that makes it legitimate to engage in certain kinds of commercial activity such as patenting or generating R&D grants from industry. Still others are making it legitimate for faculty to take sabbaticals or leaves of absence to focus on commercial projects based on work they had been doing as part of their ongoing research agenda. While these examples do not mitigate the fact that conflicts of interest are real and require vigilance in addressing, it is also clear that society continues to press universities to be relevant in economic development terms. Thus, finding ways to balance the historical norms of academic science (Merton, 1942) with the emerging ones characteristic of the entrepreneurial university (Etzkowitz, Webster, & Healey,1998) is necessary. Educating faculty about the processes associated with technology transfer while at the same time providing education about the conflicts of interests that can ensue and what policies and practices are in place to manage them can aid in this regard.

Incentives for Technology Transfer

This study also revealed that incentive systems for technology transfer, especially those that align with the institutional and faculty culture, appear to be important in the successful commercialization of a university developed technology. This finding also corroborates previous

research in this area (Siegel, Waldman & Link, 2003). What this study adds to the literature, however, is the ways in which the various participants in the technology transfer process view the incentives as a motivational tool. Faculty, for instance, appear to be motivated by income augmentation opportunities available through licensing royalties. Yet, they also desire to see the benefits of their work accrue to their research program or lab as well as to their department as a whole. These latter elements enhance their ability to do what they ostensibly love, conduct leading edge research and be a member of a high quality department.

Technology transfer offices also seem to be aware of actions that they can take to incentivise technology transfer beyond the sharing of royalties with the inventor. Engaging in such actions as holding recognition banquets, awarding plaques for patent recipients, and writing letters of recommendation for faculty seeking tenure, promotion, or undergoing a performance review do seem to matter to faculty, especially given the criticism they may feel from some colleagues over their involvement in commercially related activities.

From the industry perspective, this study clearly revealed how important flexibility in licensing options is for consummating a deal. Historically, universities have been reluctant to venture far from the traditional licensing arrangement, up-front fees and scheduled royalty payments. In recent years, however, universities have been increasingly willing to accept equity in lieu of a portion of these payment expectations with some universities having been well rewarded for such actions (Bray & Lee, 2000).

In light of the fact that the majority of licensing activity is with smaller firms, the flexibility of equity substitution options is a strong incentive for firms to license technologies from universities. Not only does it reduce the pressure on the typically cash-poor small firm, it sends a clear symbolic signal that a university is serious about the partnership, since they stand to

benefit or to be hurt by the ultimate success or failure of the company. Furthermore, when the faculty member is also an equity holder, he or she may have greater psychic connection to the firm and perhaps be more likely to assist with post-licensing technical support. While the equity approach to licensing is not without risk, it does appear to result in greater chances for a licensing deal, a necessary and critical first step in any transfer of technology.

Environment of Trust and Mutual Respect

The third theme identified in this study involved an environment of mutual trust and respect. Of all the contributing factors to successful commercialization surfaced in this study, the theme of trust was the strongest one articulated by study participants. However, it was also clear that the trust factor was perhaps the most elusive, in part due to the cultural differences between higher education and the for-profit business sector. Previous research has documented these cultural differences (Thursby & Kemp, 1999) but precious little has discussed how these differences might be overcome in a manner that considers both the needs of industry and the conflict of interest concerns of the academy. This study suggests some ways that the trust and respect issues can be kept while still allowing for the distinct cultural and mission elements characteristic of each contributor to the technology transfer process.

One way that trust and respect between the faculty inventor, the technology transfer office, and the licensing firm can be proactively addressed could come through intentional training and workshop sessions. One model might be to use faculty with considerable experience with technology transfer to educate their peers on the processes involved with commercial activities and to engage them in a discussion of their impressions and misimpressions about its practice. Furthermore, respected faculty leaders in technology transfer

could help other faculty recognize their own limitations and thus in turn help them to see the value of technology transfer professional assistance.

An enhancement to the above model would be to involve licensing professionals from the business side as well. These persons could help faculty see the issues from the firm perspective including their contribution to the value enhancement process of a technology. Additionally, firm professionals could share how post-licensing involvement of the inventor is often important and how being engaged in this way can also advance a faculty member's own research and consulting agenda. Finally, an open and frank discussion among all parties regarding conflicts of interest concerns and expectations can further reduce the potential for mistrust.

In addition to the above possibilities for trust enhancement, universities might also expand their technology transfer office professional staff to include entrepreneurs in residence, something that a few institutions are currently doing. Historically, university technology transfer professionals have come from inside universities, usually after having spent some time as a faculty member or researcher in the life or physical sciences. More recently, professionals with business or legal experience are being hired to staff some positions. Yet, few universities have intentionally sought on-staff entrepreneurs to assist with the process of starting companies, an increasingly common means of transferring technology to the marketplace. The entrepreneurs are particularly skilled at starting businesses, at finding good management to run them, and at identifying and obtaining venture capital funding, the life blood of any small company with a portfolio of pre-product phase technologies. As a trust building mechanism, the entrepreneur also serves as a valuable mediator between the cultures of higher education and the business sector, respected by both as someone who can help to resolve differences and to assist in keeping the communication channels open.

Conclusion

This study advances our knowledge of factors that may lead to the successful commercialization of an academic innovation. Although concluding that the triple-helix relationship among the faculty inventor, technology transfer office, and licensing firm is the primary source of success requires further study, the results do suggest important policy and practice implications. For researchers of university commercialization, this study offers a useful building block toward larger qualitative or quantitative inquiry of the range of entrepreneurial activities and behaviors of higher education. For practitioners, the study offers insights on how the considerable energy that is currently going into commercially oriented activities might be channeled more effectively, and ultimately, practiced more responsibly.

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